

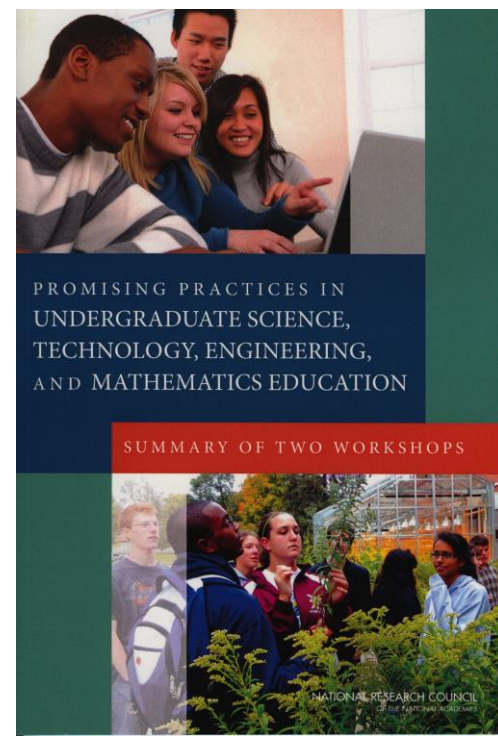
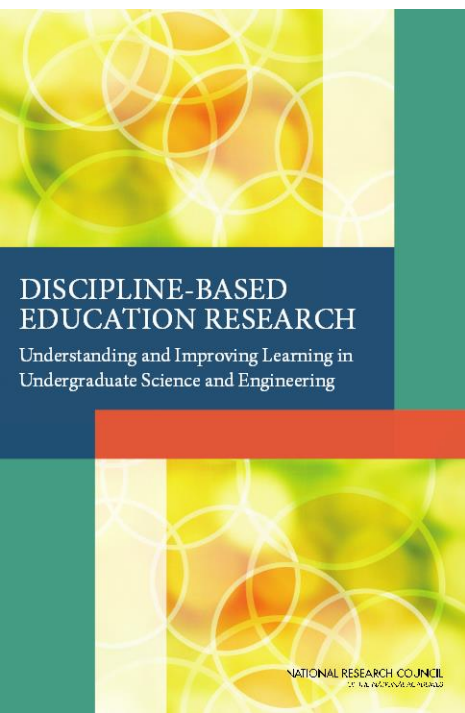
Promising Practices in Undergraduate STEM Education: Let's Implement Them

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Director, Division of Undergraduate
Education

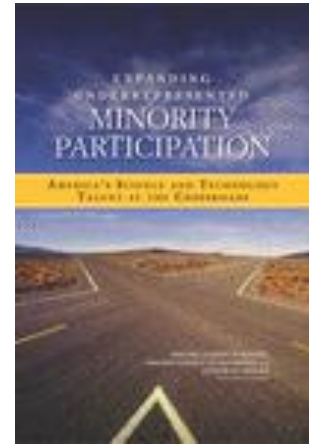
National Science Foundation
&

Departments of Biology
and Cognitive Science
Carleton College



Undergraduate Science and Engineering Education: Challenges and Opportunities

- Retaining students in courses and majors (including future science teachers)
- Increasing diversity
- Improving the quality of instruction



REPORT TO THE PRESIDENT
PREPARE AND INSPIRE:
K-12 EDUCATION IN SCIENCE,
TECHNOLOGY, ENGINEERING,
AND MATH (STEM) FOR
AMERICA'S FUTURE

Executive Office of the President
President's Council of Advisors
on Science and Technology

SEPTEMBER 2010



100Kin10

RECRUIT AND TRAIN 100,000 GREAT STEM
TEACHERS OVER THE NEXT DECADE WHO
ARE ABLE TO PREPARE AND INSPIRE
STUDENTS

100Kin10
ANSWERING THE NATION'S CALL



Office of Science and Technology Policy
Executive Office of the President
Eisenhower Executive Office Building
Washington, DC 20502

EMBARGOED for Release until
March 18, 2013 9:30 ET

Contact: Rick Weiss, 202 456-6037
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Obama Administration Announces New Steps to Meet President's Goal of Preparing 100,000 STEM Teachers

Includes major \$22.5M investment by philanthropic partners

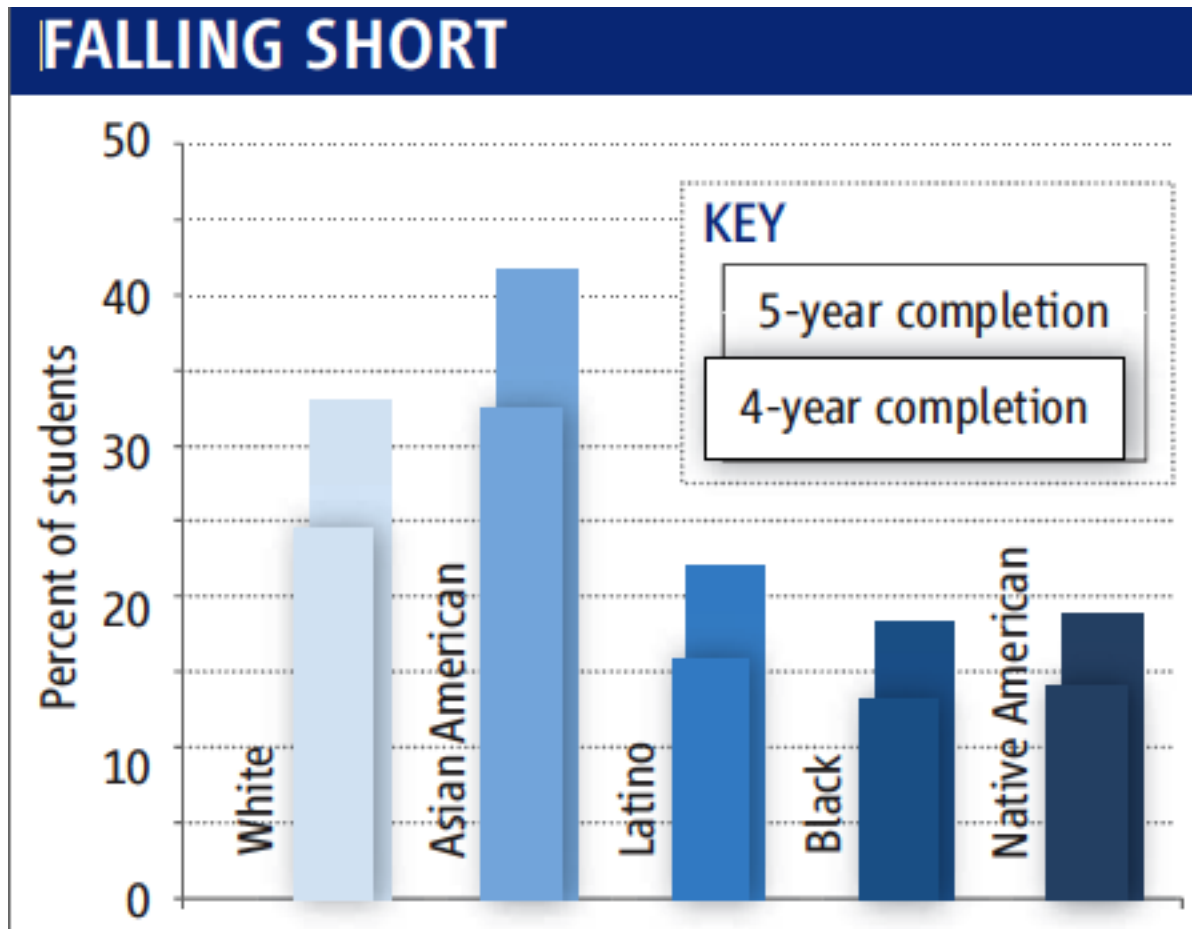
Today, the White House announced new steps by the Administration and its partners to meet the President's goal of preparing 100,000 excellent math and science teachers over the next decade. These include a new \$22.5M investment by the Howard Hughes Medical Institute (HHMI), which would approximately double the private-sector investment in the President's initiative.

CROSS-AGENCY PRIORITY GOAL



Science, Technology, Engineering, and Math (STEM) Education: In support of the President's goal that the U.S. have the highest proportion of college graduates in the world by 2020, the Federal Government will work with education partners to improve the quality of science, technology, engineering and math (STEM) education at all levels to help increase the number of well-prepared graduates with STEM degrees by one-third over the next 10 years, resulting in an additional 1 million graduates with degrees in STEM subjects.

Finishing an undergraduate STEM degree is a challenge

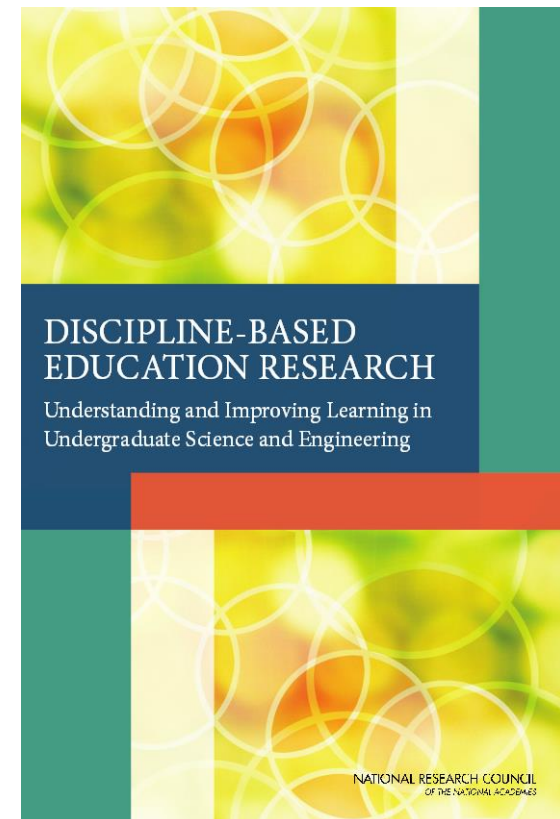
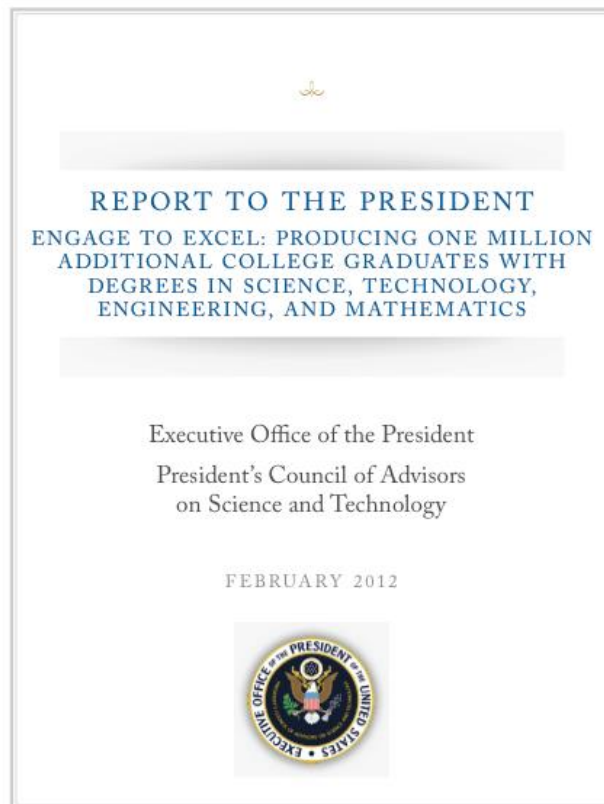


Many efforts underway to encourage widespread implementation

- NSF WIDER, TUES, Expeditions in Education
- AAU Undergraduate STEM Initiative
- APLU SMTI
- AAC&U/PKAL
- Business Higher Education Forum
- HHMI, NSF, NIH: PULSE, Vision and Change
- NGSS and new AP curricula with implications for higher education
- University initiatives (e.g. CU, OU, U MD system)
- Scaling of UTeach, Project SCALEUP

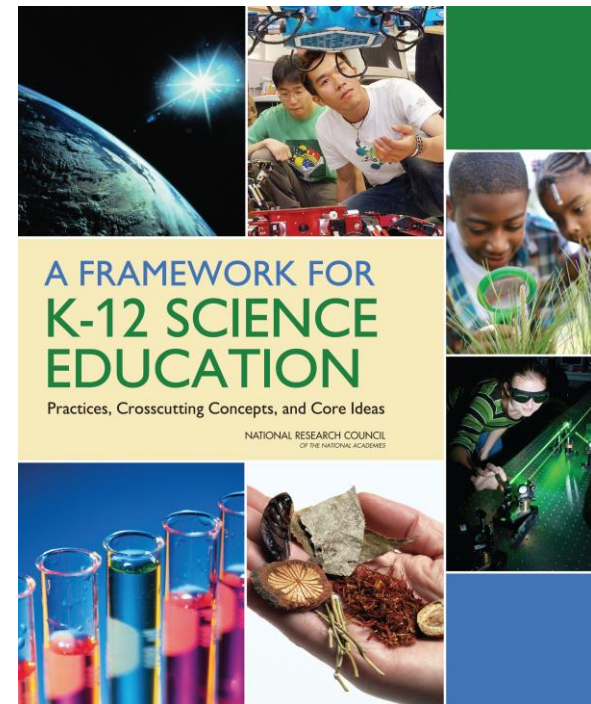
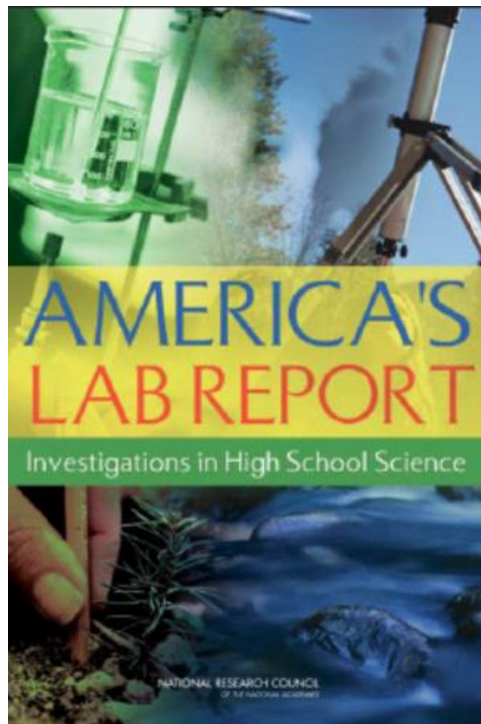
PCAST “Engage to Excel”

- Recommendation 1: Catalyze widespread adoption of empirically validated teaching practices



PCAST “Engage to Excel”

- Recommendation 2: Advocate and support replacing standard laboratory courses with discovery-based research courses.



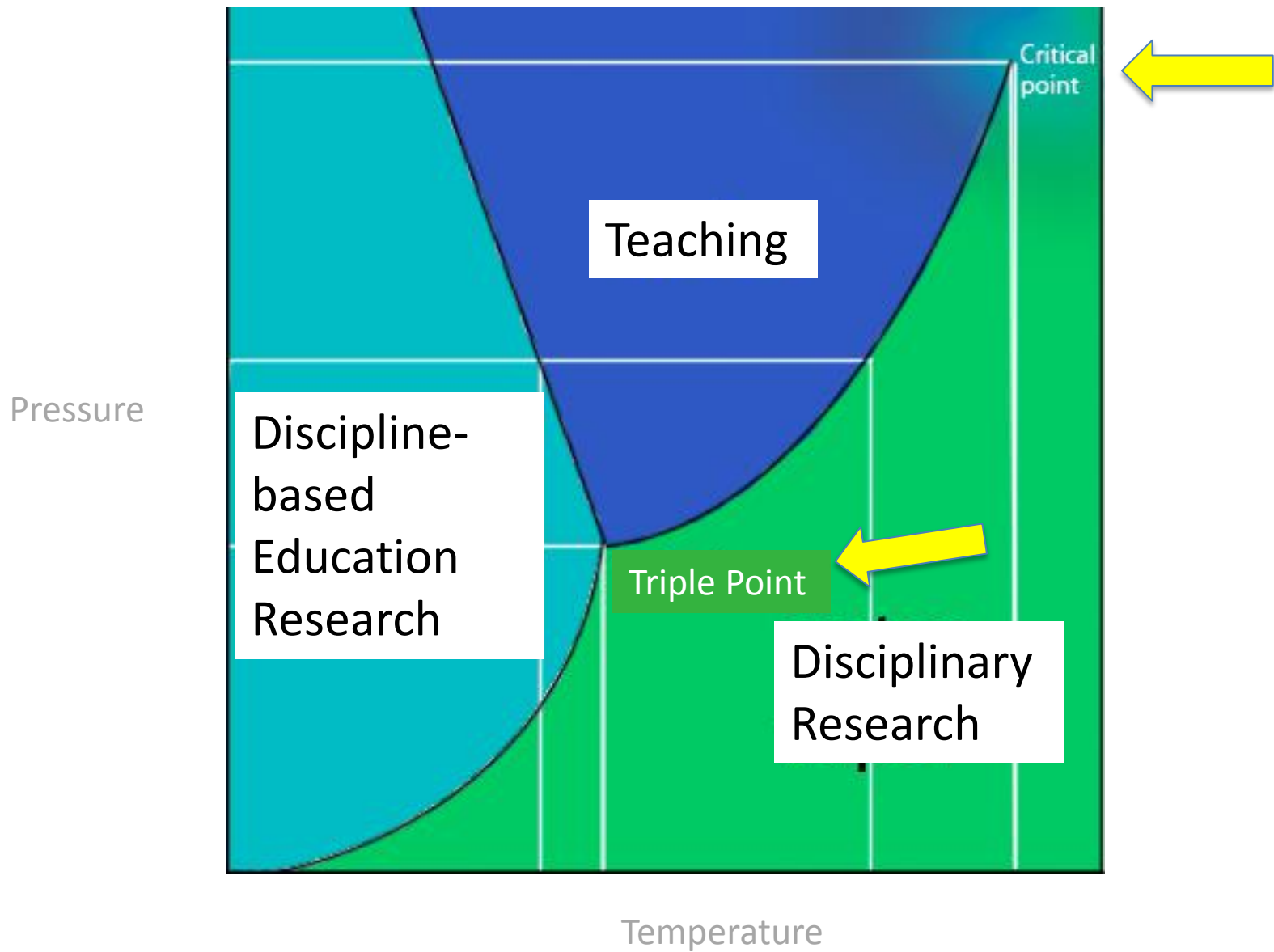
Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research

- **SUSAN SINGER** (Chair), Carleton College
- **ROBERT BEICHNER**, North Carolina State University
- **STACEY LOWERY BRETZ**, Miami University
- **MELANIE COOPER**, Clemson University
- **SEAN DECATUR**, Oberlin College
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- **WILLIAM B. WOOD**, University of Colorado

What is Discipline-Based Education Research?

DBER

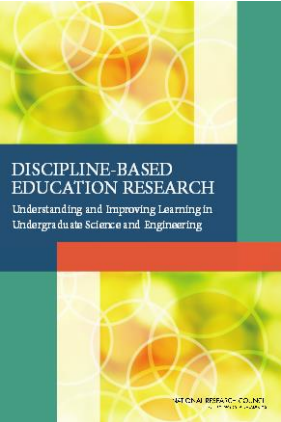
- Investigates teaching and learning in discipline using a range of methods with deep grounding in the discipline's priorities, worldview, knowledge, and practices
- Informed by and complementary to
 - Cognitive science
 - Educational psychology
 - K-12 education research



DBER Goals



- Understand how people learn the concepts, practices, and ways of thinking of science and engineering.
- Understand the nature and development of expertise in a discipline.
- Help to identify and measure appropriate learning objectives and instructional approaches that advance students toward those objectives.
- Contribute to the knowledge base in a way that can guide the translation of DBER findings to classroom practice.
- Identify approaches to make science and engineering education broad and inclusive.

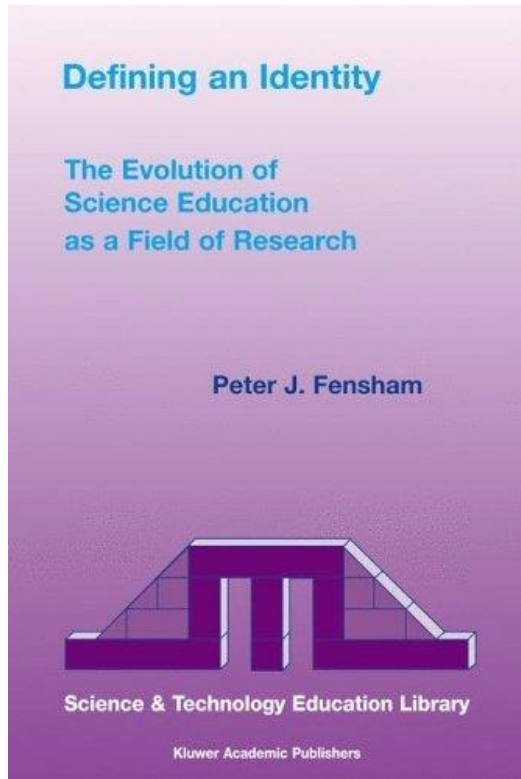


Baseline Information from DBER Study Charge

- Synthesize empirical research on undergraduate teaching and learning in physics, chemistry, engineering, biology, the geosciences, and astronomy.
- Examine the extent to which this research currently influences undergraduate science instruction.
- Describe the intellectual and material resources that are required to further develop DBER.

Emergence & Current Status of DBER

(Parallels to challenges/changes in K-12 STEM education in 70s & 80s)



1. Structural Criteria

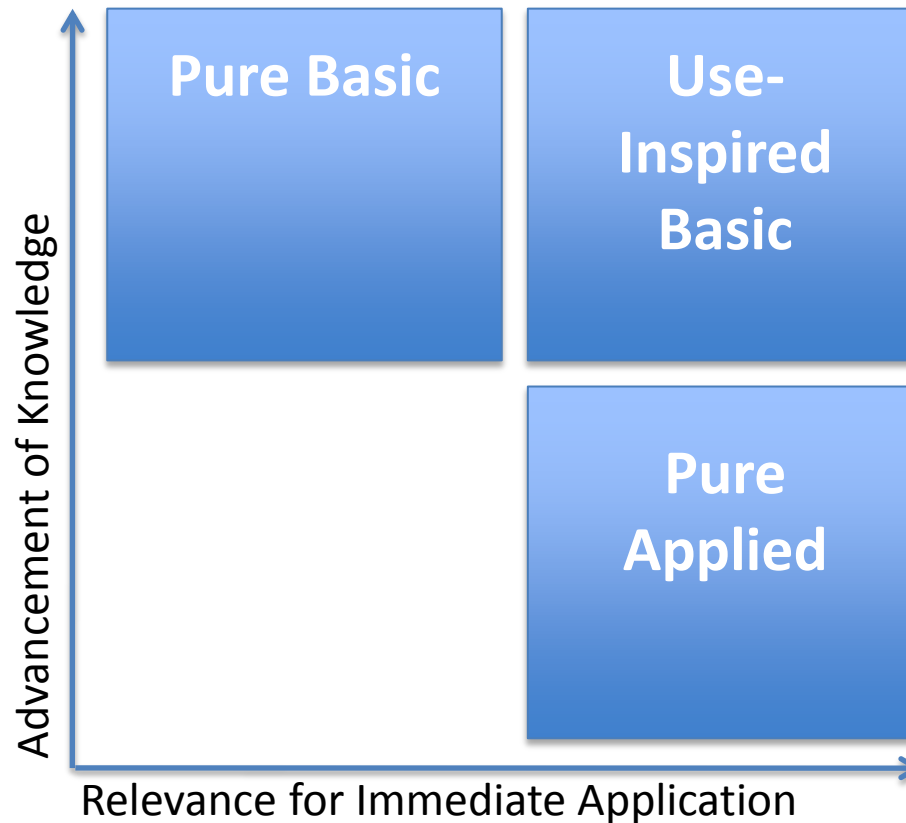
- a. Academic recognition
- b. Research journals
- c. Professional associations
- d. Research conferences
- e. Research centers
- f. Research training

2. Intra-Research Criteria

3. Outcome Criteria

Fensham, P.J. (2004). *Defining an identity: The evolution of science education as a field of research*. Boston, MA: Springer.

DBER Designs: Pasteur's Quadrant



Stokes, D.E. (1997). *Pasteur's quadrant: Basic science and technological innovation*. Washington, DC: Brookings Institution Press.

Types of Knowledge Required To Conduct DBER

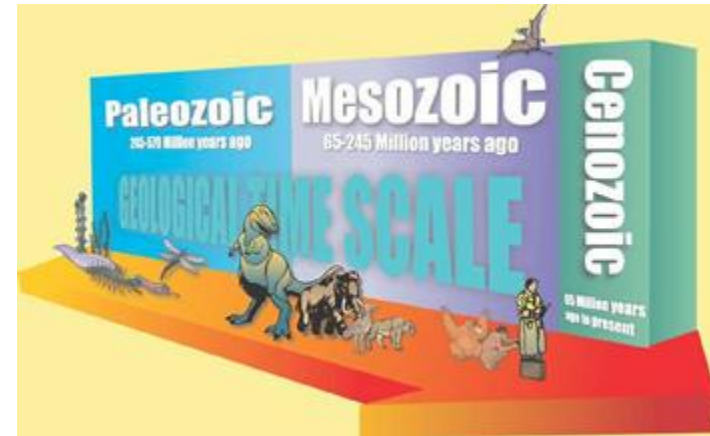
- Deep disciplinary knowledge
- The nature of human thinking and learning as they relate to a discipline
- Students' motivation to understand and apply findings of a discipline
- Research methods for investigating human thinking, motivation, and learning

Synthesis of the DBER Literature

- Students' conceptual understanding (Ch. 4)
- Problem solving (Ch. 5)
- Use of representations (Ch. 5)
- Effective instructional strategies (Ch. 6)
- Emerging topics (Ch. 7)

Contributions of DBER: Conceptual Understanding and Conceptual Change

- In all disciplines, undergraduate students have incorrect ideas and beliefs about fundamental concepts. (Conclusion 6)
- Students have particular difficulties with concepts that involve very large or very small temporal or spatial scales. (Conclusion 6)



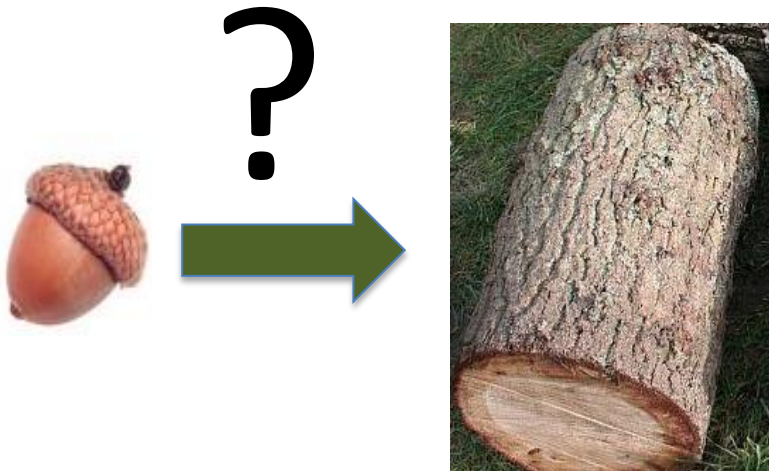
Contributions of DBER: Conceptual Understanding and Conceptual Change

- Several types of instructional strategies have been shown to promote conceptual change.



Contributions of DBER: Conceptual Understanding and Conceptual Change

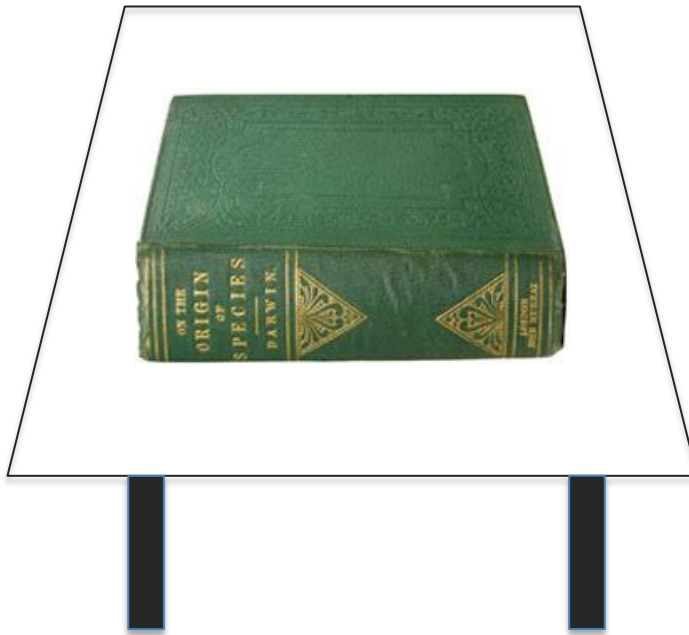
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Interactive lecture demonstrations

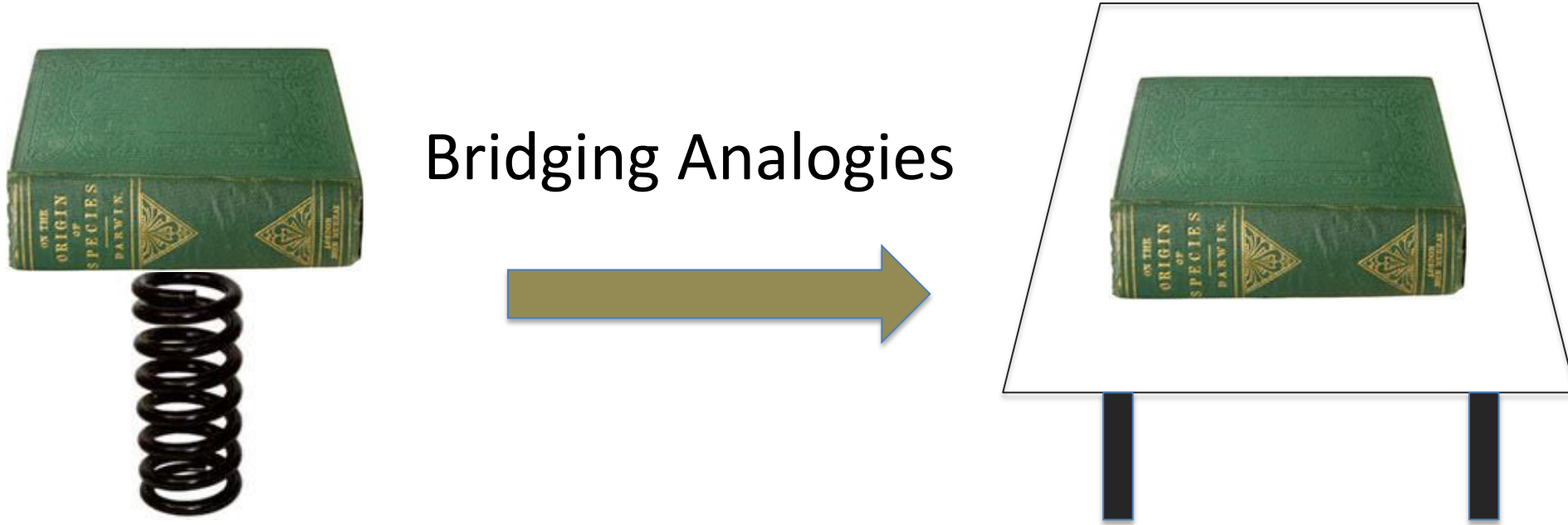
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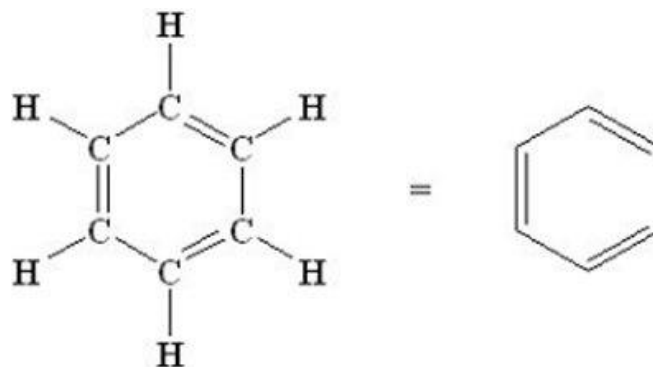
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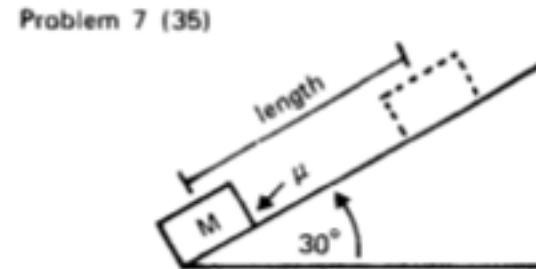
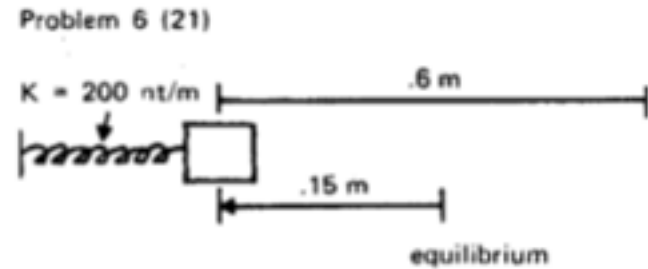
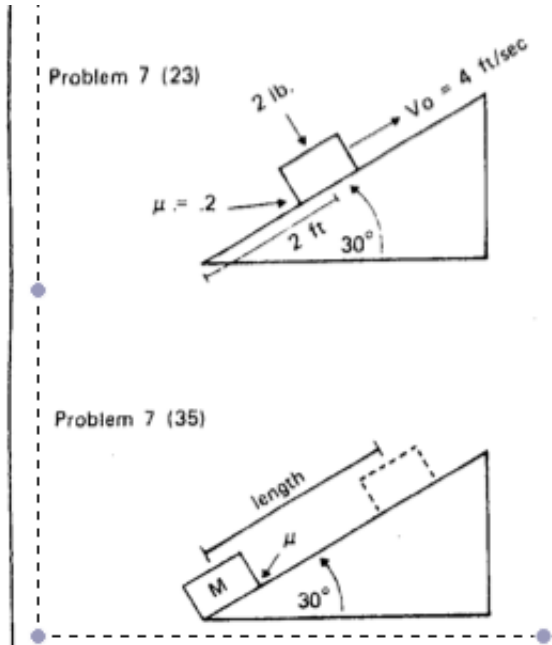


Contributions of DBER: Problem Solving and the Use of Representations

- As novices in a domain, students are challenged by important aspects of the domain that can seem easy or obvious to experts. (Conclusion 7)
 - Superficial details
 - Working backward
 - Expert blindspot



Problem Solving and the Use of Representations



Novice: Inclined plane problems

Expert: Conservation of energy problems

Chi, M. T. H., Feltovich, P., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, 5: 121-152.

Contributions of DBER: Problem Solving and the Use of Representations

- Students can be taught more expert-like problem-solving skills and strategies to improve their understanding of representations.
 - Socially-mediated learning environments
 - Open-ended problems
 - Interventions to promote metacognition
 - Scaffolding (steps and prompts to guide students)
 - Use of multiple representations

Contributions of DBER: Research on Effective Instruction

- Effective instruction includes a range of well-implemented, research-based approaches.
(Conclusion 8)
- Involving students actively in the learning process can enhance learning more effectively than lecturing.



Contributions of DBER: Research on Effective Instruction

- The use of learning technology in itself does not improve learning outcomes. Rather, how technology is used matters more.
- DBER can inform MOOCs



Future Directions for DBER: Some Key Elements of a Research Agenda

- Studies of similarities and differences among different groups of students
- Longitudinal studies
- Additional basic research in DBER
- Interdisciplinary studies of cross-cutting concepts and cognitive processes
- Additional research on the translational role of DBER

Future Directions for DBER: Translating DBER into Practice

- Available evidence suggests that DBER and related research have not yet prompted widespread changes in teaching practice among science and engineering faculty. (Conclusion 12)
- Efforts to translate DBER and related research into practice are more likely to succeed if they:
 - are consistent with research on motivating adult learners,
 - include a deliberate focus on changing faculty conceptions about teaching and learning,
 - recognize the cultural and organizational norms of the department and institution, and
 - work to address those norms that pose barriers to change in teaching practice. (Conclusion 13)

Future Directions for DBER: Recommendations for Translating DBER Into Practice

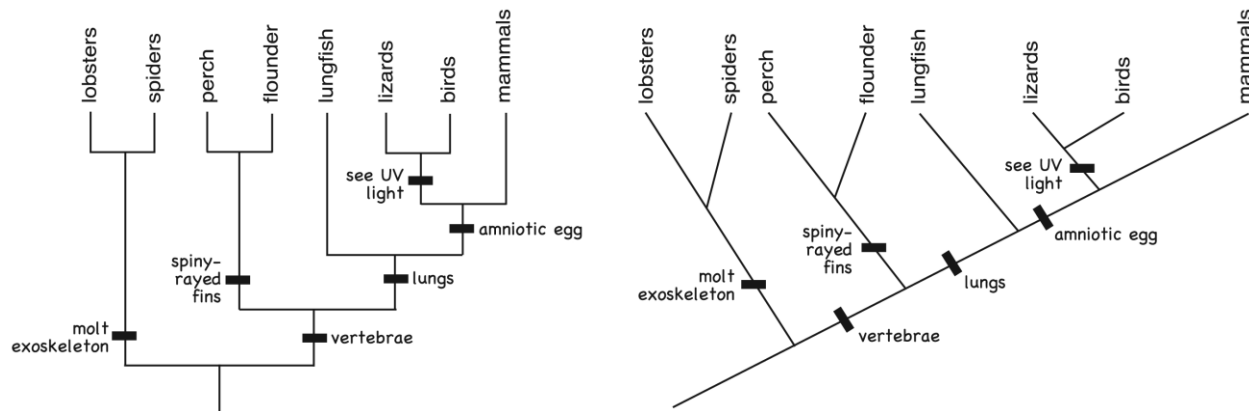
- **RECOMMENDATION:** With support from institutions, disciplinary departments, and professional societies, faculty should adopt evidence-based teaching practices.
- **RECOMMENDATION:** Institutions, disciplinary departments, and professional societies should work together to prepare current and future faculty to apply the findings of DBER and related research, and then include teaching effectiveness in evaluation processes and reward systems throughout faculty members' careers. (Paraphrased)

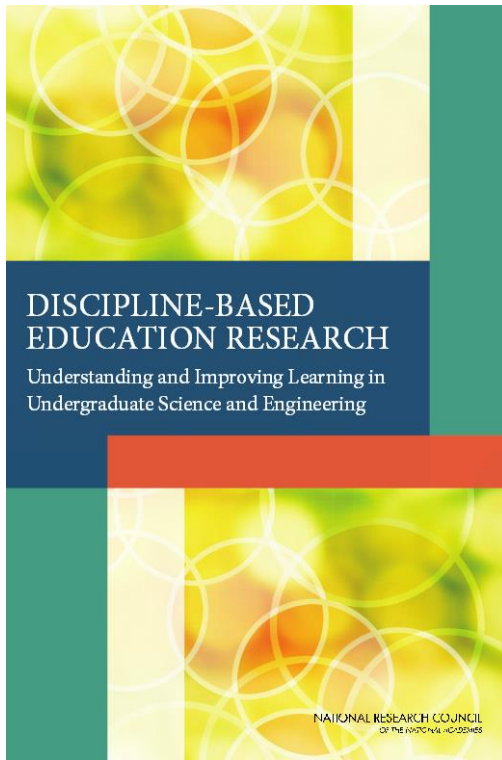
Future Directions for DBER: Research Infrastructure

- Advancing DBER requires a robust infrastructure for research. (Conclusion 16)
- **RECOMMENDATION:** Science and engineering departments, professional societies, journal editors, funding agencies, and institutional leaders should:
 - clarify expectations for DBER faculty positions,
 - emphasize high-quality DBER work,
 - provide mentoring for new DBER scholars, and
 - support venues for DBER scholars to share their research findings

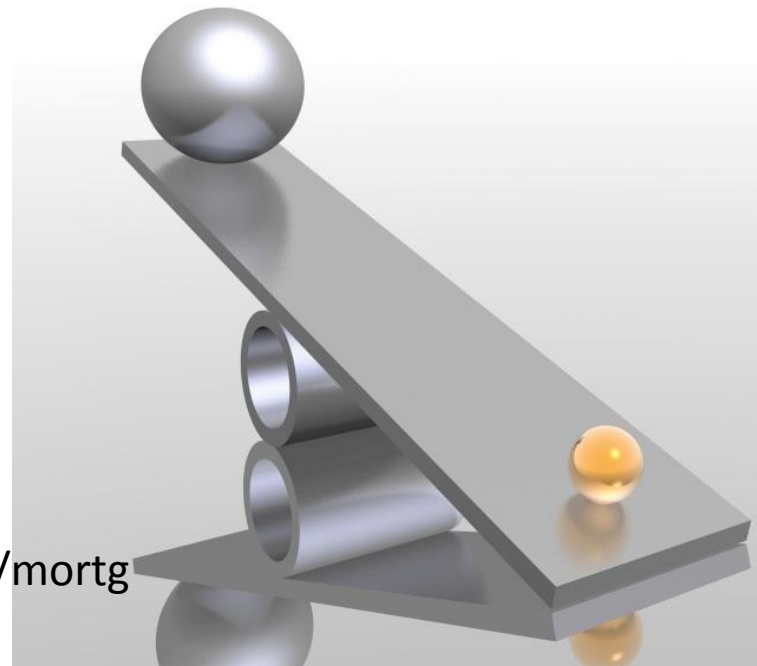
Future Directions for DBER: Advancing DBER through Collaborations

- Collaborations among the fields of DBER, and among DBER scholars and scholars from related disciplines, although relatively limited, have enhanced the quality of DBER.
(Conclusion 15)





Promising Practices in Undergraduate Science and Engineering Education: Let's implement them!



<http://mortgagenewsandrates.com/2012/03/06/mortgage-rates-see-saw-back-and-forth/>

Acknowledgements

- National Science Foundation, Division of Undergraduate Education (Grant No. 0934453)
- Various volunteers:
 - Committee
 - Fifteen reviewers
 - Report Review Monitor (Susan Hanson, Clark University) and Coordinator (Adam Gamoran, University of Wisconsin-Madison)
- Commissioned paper authors
- NRC staff (Natalie Nielsen, Heidi Schweingruber, Margaret Hilton)